

once again being trained in large numbers in almost every part of the Dominion. The influence of this new blood has already begun to make itself felt in the building trades, particularly where veteran trainees are concerned, and there is no question but that these newcomers can be relied upon to play an important and steadily increasing part in raising the average level of efficiency of the entire Construction Industry.

Another reliable expectation is that the further development of pre-fabrication and pre-assembly methods and improvements in mechanization techniques will do much to reduce today's high factory and "on site" labour costs, particularly as related to house construction.

Generally speaking, it is apparent what the Construction Industry needs most of all to-day is a re-vitalizing incentive spirit which can be created only by providing fixed price targets to shoot at. There would be no insurmountable difficulties standing in the way of the setting up of these targets, provided they are set up through the joint action of labour and management. Why is so little being done to this end?

The setting up of these fixed price targets would mark the turn of the tide and costs would immediately start to decline rather than to go on rising. The decline would in all probability be a whole lot slower in action than was the rise but there would always be the

satisfaction of seeing things headed the right way instead of going in the wrong direction. Moreover, confidence would be restored.

Just how low costs may be expected to go below today's high levels once they do start to decline is purely a matter of conjecture. If anything like the present standard of living is to be maintained, it would appear to be unreasonable to believe that building costs would ever be likely to drop back on the average more than half way to where they were in 1939, at the very most.

The hope is that the high building cost tide will turn ahead of the development of any recession which might so easily prove to be the forerunner of another depression.

It has long since been accepted as axiomatic that the Construction Industry functions as a barometer in the field of national economics. Events have gone to prove time and time again that there can never be any general prosperity without a high level of activity in construction. This being the case, any sustained recession in the building business serves as a storm signal for business generally.

If high prices now wreck the Construction Industry, our hopes for post-war reconstruction will go by the boards. This is the cold, hard fact of the matter and it behooves all who have the interest of Canada at heart to never lose sight of that fact.

## Technical Progress: A Factor in the Housing Program

By D. C. SIMPSON

THE problem of producing houses within the economic reach of the mass market has vexed housing technicians for more than a decade. This problem is not confined to Canada alone, but constitutes an increasingly acute need all over the world today. It must

be realized that this housing problem is not entirely war-created but is partially the result of the ever-increasing inability of the construction industry to meet the demands of the great majority of people for well-constructed homes within their means to pay for them. The inability is, of course, a complex product of many factors—economic, social, and to no small degree, technical—and progress in

the technical sphere may indeed hold an important key to the eventual solution of this pressing problem. It is impossible, however, to give consideration in this article to every aspect of technical progress in all fields of construction, but we can review specific advances in industrial techniques which give great promise and which indicate a trend likely to be of significance in our future building methods.

A measure of technical progress has been made in this country, but our conception of building techniques remains essentially archaic and our builders are still, for the most part, employing the crafts and skills developed by our forefathers. The building trades of carpentry bricklaying, plastering, and so on, are technically centuries old; and even much that goes today under the name of prefabrication consists merely of site assembly, in a horizontal position, of frames or walls, which are then raised and fastened. In other words, it is merely going back to the framed, wood-building techniques of the seventeenth and eighteenth centuries, with their barn-raising. We have now added the mechanical trades of plumbing, heating and electrical to the list, and the resultant confusion and delay on the building site are now multiplied beyond all reason in this age of industrial efficiency. We have not taken full advantage of new techniques and industrialized methods of production, and consequently the building industry lags far behind others, both in its capacity and in the price and quality of its product.

Many reasons can be cited for this lag. One is the fact that housing is as intimate a human concern as food or clothing, and progress has been slow in shelter because the house is the family's social face and the family's clothing. Most humans refuse to consider their home as merely scientific shelter. To most of us it is an instrument of social continuity which binds the family together, and, when it is grouped into community units, tends to bind the social group together. Thus, while technical

progress is desirable, these emotions must be taken into consideration. But at the same time, if real advances toward a technical solution are to be expected, these emotions must not vitiate the scientists' thinking.

### Building Progress in Other Countries

One cannot review building progress in any country of the world without becoming aware of the increasingly large part that industrial processes and scientific research play in the development of new materials and the manufacture of building elements, and through these to a material solution of many of these countries' construction problems.

For example, in Great Britain the problem of reconstruction became suddenly acute with the end of this last destructive war and steps were taken to face it squarely; and because of the well organized way in which these problems were analyzed and attacked, it may be worth noting some of the results of the British approach.

Of the million building operatives on the prewar strength, some 400,000 remained in 1945, and of these only 7,000 were under 41 years old. With this depleted labor force, a huge estimated deficit of some four million dwellings had to be erected during the first ten years after the war, and a huge reconstruction program of schools, hospitals and commercial buildings as well as repair and restoration work had to be done. It was fairly obvious that most of the elements of these buildings had to be mass-produced when it was realized that with no material supply problems such as exist today, it took twenty years to produce the four million houses built between wars by orthodox methods.

The Ministry of Works appointed a Controller of Experimental Building Development, and a panel of technical officers was formed to assist him in the work of preliminary examination of technical background of information in industrialized building systems and the re-

search which should have been going on over a number of years had to be compressed into months. Fortunately, the Building Research Station had undertaken the examination of several systems in the 1920's and the published results of their examinations helped the experimenters to avoid many of the common pitfalls. It also meant that there were a number of men at the Building Research Station whose technical knowledge was of inestimable value.

Much fundamental work is now being done by both government and industrial scientists toward producing processed wood and timber substitutes at reduced costs, and light-weight concrete aggregates, any of which may well have considerable influence upon future building methods in the United Kingdom, since there is now close cooperation with the building industry and work progresses towards the direct application of this scientific knowledge to current building processes. Development, as well as research, is now coordinated and several planned housing developments have been constructed, employing the most advanced thought in community layout as well as building techniques. Pilot plants have been set up, and at the present time from twenty to thirty different prototypes for permanent postwar house construction are being or have been built. The prefabricated types can be divided broadly into those having a steel, reinforced concrete or aluminum frame, those using precast concrete slabs for pier and panel work, those with large composite units framed in timber, and the stressed skin plywood types. There are also proposals for simplified or prelaid brickwork and for "in situ" concrete using various types of formwork. Those that use timber lavishly are not encouraged, since it is unlikely that timber will be freely available in Britain for a number of years.

One or two systems employing aluminum, steel, concrete and brick are now on a mass production basis and have done much to alleviate the critical housing

situation of numbers of people without shelter of any kind.

Thus, while the trend in low-cost housing in Great Britain is swinging toward greater industrialization, it has not been suggested that the present methods of building ought to be entirely and immediately superseded by complete industrialization of building. Results may well be achieved by a proper balance between the traditional and industrialized methods of construction—with the latter concentrated in the field of low-cost housing as the movement toward full industrialization begins.

In the United States, on the other hand, a much different situation exists. The great proportion of industry-produced houses use wood as the basic structural material. This is natural since almost unlimited supplies of timber are available in the U.S. This fact has contributed greatly both to experiment and to production using wood in factory-made houses.

Because of its long experience in mass production, the United States has produced some technical developments which are very promising—and possibly in advance of most other countries. But the rather haphazard policy with respect to the coordination of these developments leaves the U.S. far behind the United Kingdom in actual progress towards achieving low-cost houses for the majority of the people through mass production techniques.

#### Utilization of Aircraft Structural Developments

For example, the United States Forest Products Laboratory, in 1935, built a house utilizing the "stressed skin" principle. Through the application of this principle, the bulk of the material used in the floor panels was reduced by one half and the material used in the walls by more than two-thirds. Despite this considerable saving in materials, tests showed that the resulting structure was three times as strong as was needed to meet average loading conditions. The

term "stressed skin construction" is used to describe a structure, the strength of which resides in its surface skins or faces. These are usually separated and stabilized by intermittent members parallel to the load—very much like the studs in a conventional frame structure but much lighter in section. Structures of this type have been made possible by development of synthetic glues of great strength, by advances in the use of thermo-setting plastics, and by the development of structural sheet materials including plywood, asbestos board, sheet aluminum. Because these materials are processed in their manufacture they possess uniform strength without local flaws, and are so efficient that reliable design criteria can be easily obtained. The structure can therefore be designed accurately and without the tremendous safety factors for which allowance must be made in the conventional construction where the sheet material, such as wood sheathing, cannot be relied upon to carry any vertical loads and, as a result acts structurally only as cross bracing and goes along with the studding merely for the ride.

This practical technical development has since influenced many companies currently producing factory-made houses and a large proportion of these firms are now employing the principle in many sections of their houses. However, a thoroughly thought-out system of panel construction was not employed and much was left to the individuals wishing to employ the principle insofar as the method of connection and the panel dimension or module was concerned. Thus, a spasmodic and sometimes irrational use of the principle has been made by industry, and the full value of this development has not as yet been realized.

Several research organizations, both private and government, namely, John B. Pierce Foundation, Bemis Foundation and the U. S. Forest Products Laboratories, are currently attempting to apply to house construction, war-developed

techniques in aircraft structures, particularly "sandwich" construction. This type of construction, which eliminates most of the rib framing in aircraft by using a lightweight core material to stabilize the structural skin material, has produced some very interesting possibilities for the efficient use of materials in building construction.

In sandwich construction, structural sheet materials such as plywood, asbestos board or aluminum, which have both high strength and high density, are bonded to each side of a relatively low-density, low-strength core which is usually porous and a good insulator. The core material by itself may not be able to withstand any appreciable load, but it serves to stabilize the faces of the panel and prevents their buckling under compressive or shear loads. This type of panel is extremely efficient. Every ounce of material is working to carry the load with resulting very high strength to weight ratios. The core itself eliminates all structural framing and provides insulation and fire resistance because of its multiple dead air cells, as well as structure, because of the stabilizing effect upon the facing material.

These developments of course are only economical now because of the development and reduction in costs of synthetic resins with which it is now possible to bond practically any variety of materials securely and permanently together. The implications in the use and assembly of these materials point in only one direction—the fully industrialized house or, preferably, building elements. And because of the fact that these techniques can only be employed economically and efficiently in a factory under controlled conditions of temperature and workmanship, it leads inevitably to the conclusion that ultimately the low-cost house will be achieved only by factory methods. This will mean too, that steady year-round employment can be expected in the building industry when production is sufficient to fully utilize mass production techniques.

### Current Attempts at Solution

The existing construction industry, for the most part, in attempting to solve the cost reduction of house-building has resorted to the standardization of house plan, multiplying these plans by the thousands and saving by site fabrication and organization. This has produced some extremely dull and monotonous developments with variety expressed only by superficial changes in the houses by the use of different colors of roofs, shutters, etc., and by site arrangement. This is true too of the majority of factory-made houses in both the U.S. and Canada, where the same traditional skills have merely moved to the factory to cut and fit the same materials by the same old methods on an assembly line instead of on the site and, as a result, the finished house, when erected, costs the consumer no less than if built by orthodox methods.

There are, however, several manufacturers in the U. S. who are exceptions and are employing high frequency glueing presses, synthetic resins, and processed sheet materials for the production of panel systems of construction capable of flexible planning arrangements. It is with the future perfection of panel systems based upon a standardized module or panel-dimension that the ultimate solution of the problem of the change-over of building from handicraft methods to full industrialization may possibly be expected. The production of building elements rather than complete house units permits full employment of industrial techniques and new materials, and can substantially reduce cost through mass production—and still permit infinite variety in the resultant product, limited only by the architect's imagination.

### Advantages of Modular Design

If an architect designs with a module dimension for which, because of general acceptance of the standard on the part of manufacturers, he can order furniture, closet elements, built-in units of all kinds with perfect confidence that they

will fit, the freedom he will gain in design and the practical advantages that would ensue would be tremendous. Economically such acceptance would be a great advantage to the building industry. The competitive position of manufacturers would really be improved by agreement on such simple matters—as, for instance, the brick industry was undoubtedly vastly helped by standardizations on the size of bricks.

Aesthetically, our architecture too might stand to gain greatly from the discipline resulting from the use of modular dimensions or panel systems of construction. There would be inevitably a kind of rhythmical continuity in design. There would be further emphasis on horizontal serenity and a quietness of effect, resulting from repetitions of certain units within a variety of compositions. It is noteworthy that in the past some of the greatest monuments of architecture, like the Parthenon, have been achieved through the gradual study and refinement of perfectly-accepted general forms. Something of the same might conceivably follow from the disciplines of modular design caused by industrial development.

It is doubtful, however, if there will be any basic changes in materials or construction methods used in houses of higher cost for many years to come. Many new materials will undoubtedly be used, but in essentially traditional ways. There is already a strong trend toward modular standardization of dimensions and this may in time become general practice. But it is in the field of low-cost houses that the long existent trend towards industrialization can be expected to be first manifest before it expands to the luxury type dwelling.

The cost of land, materials, craft labor, services and financing all combine to raise the cost of shelter in this country to a level where only the luxury-buying income groups can afford decent living standards. A technical solution alone may not be able to overcome the economic and social problems, but at least a rational system of construction utilising to

the full our tremendous fund of technical knowledge in industry and science can eliminate most of the physical difficulties in producing a low-cost construction system.

### Reorganization of Technical Resources

Is such a thing possible in time to alleviate the present shortage of low-cost dwellings? It most assuredly is, if a concentrated effort is made by our scientists, industrialists, and government. Already some steps have been taken by the government in the recent formation of a Division of Building Research within the National Research Council of Canada, and work is in progress on a fully industrialized panel system for low-cost houses. Some fundamental work in the building field has been already carried out by various scientists, particularly in regard to insulation materials, heating, concrete, plastics, wood products, etc. While some effort has been made recently to make use of the work of these scientists by a small development group within the National Research Council, it is hoped that a working arrangement can be made with industry and the building professions to employ the results of research and development so as to be immediately effective in the housing program. The government has begun to recognize this necessity by establishing some facilities for the purpose of testing building materials, new and old, and for making a beginning in putting building on a scientific basis. A laboratory for Building Research and Industrial Chemistry is to be built, and Mr. Howe, the Minister of Reconstruction and Supply, recently stated in answer to a question in the House as to the type of research to be carried on in connection with housing:

"The conductivity of housing materials strength of materials, substitutes for materials, heating, radiant heat, and various innovations in housing. The purpose of the laboratory is to test their efficiency and recommend their use or otherwise." (Hansard, July 11 '47.)

This is a definite step. But the problem will be to carry research work beyond the basis of simple material and structural testing to the full development of the resources to be found in the various fields of science, and to promote close affiliation with industry. It is therefore to be hoped that teams of chemists, engineers, physicists and architects will be formed within the Division of Building Research with the object of assessing the practical implications of the results of investigations undertaken, and passing the information on to industry in such a form that it can be applied with little further development.

The methods of fabricating elements and assembly of these components is only one part of the whole picture. But if technical progress can be tied in with the investigation of the division of land and services and a mathematical basis of physical and financial arrangements throughout, it will be of inestimable value in the solution of our housing problem. And if the technique of mass production and assembly of standardized elements designed primarily for industrial manufacture, can be developed in time to be put to immediate use on a national scale, the low-cost house may not be a pipe dream but, instead, a positive reality. We have the materials, the factories, the production "know-how", the technical and scientific knowledge. The harnessing of these necessary resources in a dynamic and coordinated effort can be a major factor in solving Canada's housing problem.